

Stratigraphy and Palaeontology of the Ordovician–Silurian boundary interval, Anticosti Island, Quebec, Canada

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Synopsis

Anticosti Island provided the principal alternative boundary stratotype to Dob's Linn, Scotland, for the base of the Silurian System. It represents the best exposed, most fossiliferous, continuous section across the systemic boundary and has virtually all the attributes required of a stratotype. The 1100 m Upper Ordovician–Lower Silurian (Richmondian to Jumperian stages) sequence of limestone with minor shale represents deposition in a marginal carbonate basin. The latest Ordovician Ellis Bay and earliest Silurian lower Becscie formations contain a record of eustatic sea level change and profound faunal changes. The seven members in the Ellis Bay Formation appear to reflect eustatic changes associated with the Saharan glaciation. The Ellis Bay–lower Becscie interval has yielded some 300 species of most invertebrate phyla. Correlation of this interval is best achieved through conodonts, ostracodes and palynomorphs, together with brachiopods and trilobites. There is a profound faunal change in conodonts and palynomorphs at 90 cm above the base of member 7, Ellis Bay Formation which is taken as the systemic boundary. Precise correlation of this level to the *P. acuminatus* graptolite Zone is difficult, but it probably lies at or just below this zonal level, somewhere within the upper *G. persculptus* Zone. The Anticosti sequence represents a standard reference for carbonate platform successions across the boundary and it also holds much information in regard to the processes and timing of the various faunal/floral extinctions which together form a Phanerozoic extinction event second in significance only to the terminal Permian event.

Introduction

The best exposed, most fossiliferous and complete section through the Ordovician–Silurian boundary interval occurs on Anticosti Island, Quebec. In these qualities as well as the lack of deformation, excellent preservation and diversity of faunas, Anticosti is comparable to other outstanding stratigraphical sections of Ordovician and Silurian strata such as the type Cincinnati Series, the type Wenlock Series, the Silurian of Gotland and the type Pridoli Series. Dob's Linn and Anticosti–Gaspé were the only boundary sections formally visited by the Ordovician–Silurian Boundary Working Group, in 1979 and 1981 respectively. Arguments supporting Anticosti as a boundary stratotype were advanced by Barnes *et al.* (1981), Barnes & McCracken (1981a, b) and McCracken & Barnes (1981). The I.U.G.S., however, has ratified the decision of the Ordovician–Silurian Boundary Working Group to choose Dob's Linn, Scotland, as the boundary stratotype (Cocks 1985) and this issue is considered elsewhere in this volume. However, it is the view of this author, and others, that a serious error of judgement has been made in this decision and that reconsideration should occur in the near future (Lespérance *et al.* 1987). In this paper, a general review is presented of the stratigraphy and palaeontology of the boundary interval on Anticosti. Many data were presented by workers in the volumes prepared for the Anticosti field excursion edited by Lespérance (1981). Some additional data have been published in the intervening period and some new conodont data are presented herein.

Anticosti Island lies in the Gulf of St Lawrence and is approximately 200 km long and up to 50 km wide (Fig. 1). The only town is Port Menier on the western end which can be reached by plane (Québecair) from Sept Îles on the north shore, or by ferry from Rimouski on the south shore of the Gulf. The island has a network of logging roads, reflecting the main economic activity of the past fifty years. In 1975, the island was expropriated by the Province of Quebec and converted to a hunting and fishing reserve: it has over 70 000 deer and some of North

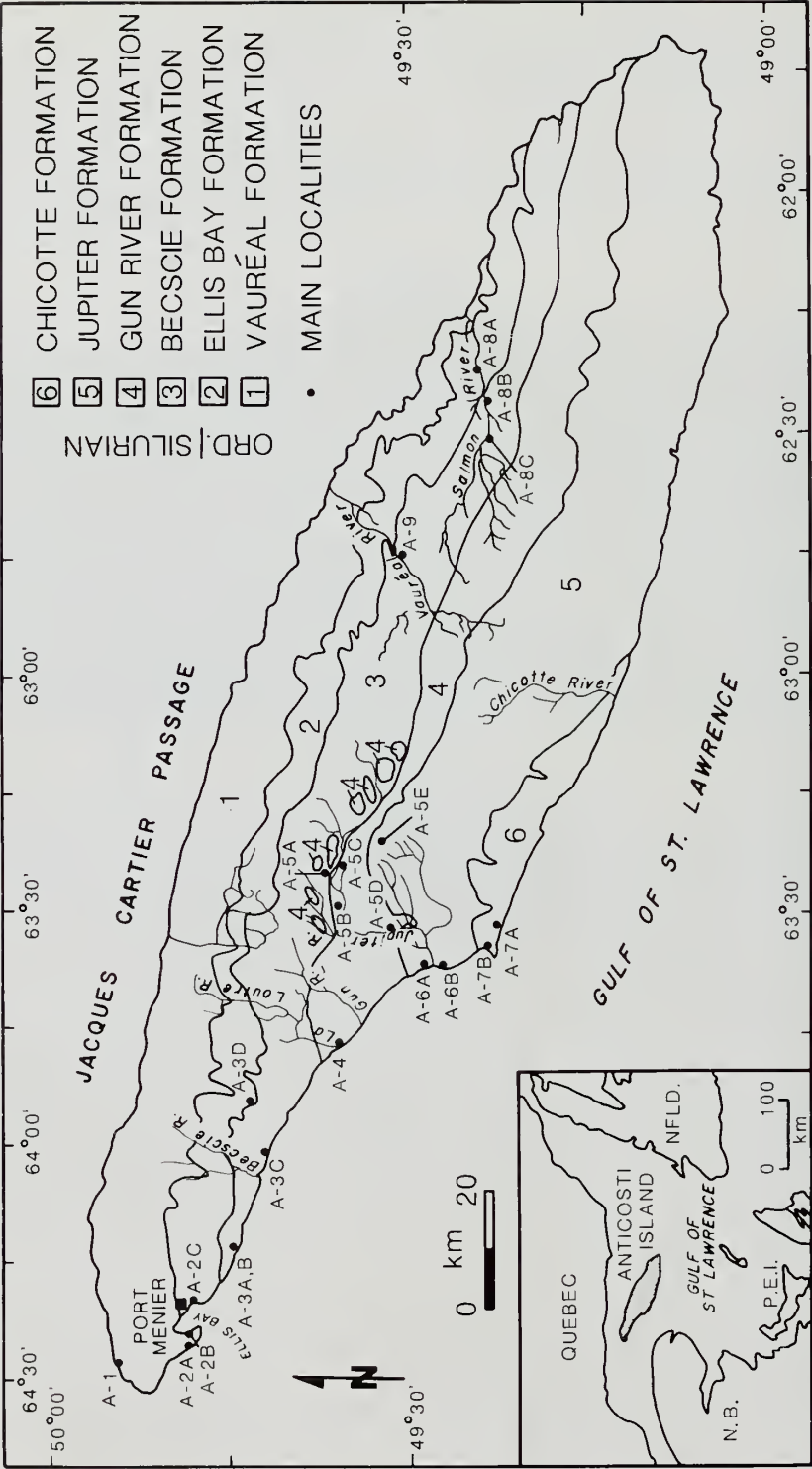


Fig. 1 Map of Anticosti Island showing distribution of formations and location of key sections described in detail in Barnes *et al.* (1981).

America's best salmon rivers. Port Menier has a hotel; cabins and camping facilities have been developed; vehicles may be rented, or ferried from Rimouski; travel to the eastern and central parts of the island requires a permit.

Stratigraphy

The island exposes an Upper Ordovician–Lower Silurian (Richmondian, Gamachian, Menierian, Jumpersian stages) succession, approximately 1100 m thick, comprising the Vauréal, Ellis Bay, Becscie, Gun River, Jupiter and Chicotte formations (Figs 1, 2). These limestones and minor shales and sandstones were deposited in the Anticosti Basin. Older parts of the succession are exposed as a discontinuous, narrow belt on the north shore of the Gulf, and in western Newfoundland. Offshore basinal equivalent strata are exposed to the south of the Logan's Line structural front in the Gaspé Peninsula. Oil exploration wells on Anticosti and seismic work south of the island have provided additional information on the regional stratigraphy (Roliff 1968; Petryk 1981*d*; Roksandic & Granger 1981). The strata dip at less than two degrees to the southwest and conodont colour alteration indices (CAI 1) indicate that burial temperatures did not exceed 80°C (Nowlan & Barnes 1987). Excellent exposure is present as cliff sections around the coast and as a wide wave-cut platform in some places; inland, exposures occur mainly along rivers and roadcuts. Key boundary sections are described by Barnes *et al.* (1981) and McCracken & Barnes (1981*a*); section numbers referred to in the former paper are also shown in Fig. 1. Space limitations do not permit a full review of previous studies (see references in McCracken & Barnes 1981*a*; Lespérance 1981). Key contributions on stratigraphy include those of Schuchert & Twenhofel (1910), Twenhofel (1914, 1928), Bolton (1961, 1972), Copeland & Bolton (1975) and Petryk (1979, 1981*a*).

During the Early and Middle Ordovician, the Anticosti Basin acted as a stable platform receiving shallow water carbonates. In response to tectonic activity of the Taconic Orogeny, the area was converted into a foreland basin first receiving the black shales of the Macasty Formation (Maysvillian), followed by 1100 m of shale and limestone of the Vauréal Formation. Only the upper third of the Vauréal outcrops at the surface on Anticosti and it forms most of the northern and western coastal outcrops. Bolton (1972) recognized that the units referred to the English Head and Vauréal Formations by Twenhofel (1921, 1928) belonged to the same formation; he proposed a lower shale and an upper limestone member. Petryk (1981*a*, *c*) recognized five informal members in the Vauréal Formation. Bolton's upper member, 150 m thick, consists of thin- to medium-bedded, grey, lime mudstone to skeletal wackestone with rare skeletal packstone, and interbedded grey shale. Intraformational limestone conglomerate and ball and pillow slump structures are common. Trace fossils are abundant; small coral-stromatoporoid bioherms occur near the top; some beds have concentrations of the stromatoporoid *Aulacera* (*Beatricea*) up to 3 m in length. Sedimentological data (Petryk 1981*a*) and conodont palaeoecology (Nowlan & Barnes 1981) indicate a general upward shallowing sequence. The numerous minor cycles in the relative abundance of the conodont genera *Drepanoistodus* and *Panderodus* (Nowlan & Barnes 1981: fig. 4) may represent climatic Milankovitch cycles which produced repetitive oceanic water mass interactions. The faunas of the Vauréal Formation suggest a Richmondian age (Fig. 2); the main study by Twenhofel (1928) was followed by others on graptolites (Riva 1969; Riva & Petryk 1981), ostracodes (Copeland 1970), chitinozoans (Achab 1977*a*, *b*), and conodonts (Nowlan & Barnes 1981).

The upper Vauréal and Ellis Bay Formations represent the final phase of infilling of the foreland basin and a return to a pattern of stable, outer carbonate platform sedimentation that persisted through the Llandovery (Anticostian). The Ellis Bay Formation, however, comprises an alternation of lithologies permitting recognition of seven members. Six of these were long recognized (Twenhofel 1928; Bolton 1972) and minor stratigraphical revision by Petryk (1979, 1981*a*) modified these to seven. This alternation has been interpreted as caused by eustatic sea-level changes associated with the Late Ordovician north African glaciation (McCracken & Barnes 1981*a*; Petryk 1981*b*; Johnson *et al.* 1981; Barnes 1986). The Ellis Bay Formation, redefined by Petryk (1979, 1981*a*) to extend only up to the level of the bioherms, is about 75 m

SYSTEM	BRITAIN		OSLO, NORWAY		SERIES	ANTICOSTI ISLAND				ARCITARCH ZONE	
	STAGE	FORMATION	STAGE	FORMATION		STAGE	FORMATION	CONODONT ZONE / FAUNA	OSTRACODE ZONE		
SILURIAN	LOWER	Sheinwoodian		Skinnerbukta	Wenlock						
		Telychian	Ceric	Jongian	Vik	Llandovery (Anticostian)		Chicotte	Pterospathodus amorphognath. Icriodella inconstans Ozarkodina aldrigei Dstaurognathoides	Zygobolba uecora	Domasia symmetrica - D. trispinosa - Multiplicisp. n. sp. - Eupoikilofusa stericula
		Wormwood						mbr. 4 Jupiter			
		Rhydings	Spirian	Rytteråker				mbr. 1-3		Zygobolba anticostiensis	
		Aeronian									
		B 1-3	Leangian	Solvik				Gun River	Icriodella discreta Icriodella deflecta	Zygobolba erecta	Tunisphaeridium tentaculaferum - Multisphaer. n. sp. - Evittia birminghamensis - Leiofusa n. sp.
	Trefawr										
	UPPER	Rhuddanian		Crychan	Bronydd	Cincinnati	Becsote			Interval Zone	
		A 2-4					m. 7 Ellis Bay mbr. 1-6				
		Scrach	Tridwr	Husbergøya			Gamachian		13 Amorphognathus ordovicicus	Jonesites semilunatus	Baltisphaer. plicatispinae - B. verrucutum
		Rawtheyan					Richmondian	Vauréal	12		
		Cautleyan					Maysvillian	Macasty	11	A. superbus	
Pusgillian											

Fig. 2 Chronostratigraphy, lithostratigraphy and biostratigraphy of Anticosti Island succession with correlations to the succession in Britain and Norway (from Barnes, in press).

thick. Members 1, 3 and 5 are more argillaceous than members 2, 4 and 6 and are more recessive; they consist dominantly of nodular, argillaceous limestone, mainly skeletal wackestone to packstone, with lenses of packstone to grainstone; interbeds and films of green and grey shale are common. These members are particularly fossiliferous with abundant brachiopods and common cephalopods, gastropods, trilobites, bivalves, aulacerid stromatoporoids, ostracodes, conodonts, and palynomorphs. Members 2 and 4 consist dominantly of thin- to medium-bedded limestone, mainly lime mudstone, with minor regular interbeds of grey shale; member 6 is a higher energy, cross laminated wackestone to packstone. Members 2, 4 and 6 are less fossiliferous than the other interbedded members, yielding sparse brachiopods, corals, aulacerids and microfossils. Member 7 consists of a basal oncolitic platform bed, 40 cm thick at Ellis Bay, which extends over most of the island and on which are developed small bioherms, typically 2 m high and 4–8 m wide (Figs 3, 4). These can be studied in vertical profile in the cliffs and in sequential horizontal profiles in the wave platform. Detailed stratigraphical descriptions of Ellis Bay Formation sections, particularly across the boundary interval, are given by Barnes *et al.* (1981) and McCracken & Barnes (1981a). The faunas of the Ellis Bay are abundant and diverse. In his pioneer study, Twenhofel (1928) described 172 species; later studies, particularly on microfossils not considered by Twenhofel, have probably doubled this figure. Twenhofel (1928) recognized that the Ellis Bay was of post-Richmondian age and proposed the term Gamachian for this latest Ordovician interval. This stage (Fig. 2) was largely ignored for half a century, but the recent Anticosti conodont work has demonstrated its validity as a North American regional stage (McCracken & Barnes 1981a; Barnes *et al.* 1981; Barnes, in press; McCracken & Nowlan, in press). Member 7 of the Ellis Bay Formation includes the Ordovician–Silurian boundary as defined on conodonts (McCracken & Barnes 1981a); the correlation of this level with the base of the *A. acuminatus* Zone at the Dob's Linn stratotype is discussed below.

The Becscie Formation was initially estimated at about 80 m thick by Twenhofel (1928) and Bolton (1972). Petryk (1979, 1981a) included most of Bolton's member 6 of the Ellis Bay Formation in the lower Becscie and his enlarged Becscie measures 131–173 m thick, with four informal members. The formation consists primarily of thin to thick bedded lime mudstone to bioturbated skeletal wackestone with brachiopod packstone and grainstone, intrarudstone, and some ball and pillow slump structures. In the upper third, packstone and grainstone are more prominent together with green shale. Much of the formation is extremely fossiliferous with concentrations of *Virgiana barrandei* (Billings) as well as corals, bryozoans and algae. Conodonts (McCracken & Barnes 1981a; Fåhræus & Barnes 1981) and ostracodes (Copeland 1974) indicate an early Llandovery age (Rhuddanian; Menierian).

Above the Becscie lie the Gun River, Jupiter and Chicotte formations. These cover the middle to late Llandovery interval and are not part of this present paper. P. Copper has been studying the brachiopods of Anticosti (e.g. Copper 1977, 1981) and preliminary results of acritarch and chitinozoan studies have been published (Duffield & Legault 1981; Achab 1981).

There have been few detailed studies of the sedimentology of the Anticosti litho-stratigraphical units. General reviews and interpretations have been given by Petryk (1981a) and in the several papers dealing with conodont faunas referred to above. Near the boundary, the sedimentology and palaeoecology of the bioherms, mainly from the eastern part of the island, was undertaken by Lake (1981). Orth *et al.* (1986) failed to detect any iridium anomaly across the Anticosti boundary interval that may have explained the systemic boundary extinctions through a bolide impact. Séguin & Petryk (1984) have produced some preliminary results of palaeomagnetic studies and J. Kirschvink and colleagues have recently begun a project to determine a possible magnetostratigraphic record in the sequence.

Palaeontology

Within the overall stratigraphy of the Anticosti sequence described above, consideration of the faunas and floras will be restricted here largely to the boundary interval.

Macropalaeontology

Graptolites. A separate paper by Riva (this volume, p. 221) reviews the Anticosti graptolite faunas.

Trilobites. Bolton (1981) reported and illustrated the most abundant and diverse of the Anticosti trilobite faunas which occurs in the upper member of the Vauréal Formation as the *Ceraurinus icarus* (Billings) Richmondian fauna. A less diverse fauna occurs in the Ellis Bay Formation and includes *Isotelus*, *Toxochasmops anticostiensis* (Twenhofel), *Otarion anticostiensis* (Twenhofel), with a member 7 interbiohermal association of *Primaspis* n. sp., *Cyphoproteus* (?) sp., *Calymene* sp. and *Amphilichas* sp. The boundary interval fauna is currently under study and preliminary results have been presented by Chatterton *et al.* (1983) and Lésperance (1985). They report that trilobite genera typical of the Ordovician disappear at the oncolitic platform bed, member 7 of the Ellis Bay Formation including *Celtencrinurus*, *Isotelus*, *Nahamia*, *Platycorpe* and *Toxochasmops*. The overlying 45 m of the lower Becscie Formation (of Petryk) does not contain diagnostic trilobites until the appearance of *Acernaspis*. Lésperance (1985) emphasizes the significance of this occurrence and infers a correlation with the *A. acuminatus* Zone. Barnes & Bergström (this volume), however, caution that its first appearance in Norway is higher, as could be its appearance on Anticosti.

Brachiopods. Lésperance (1985) has reviewed the boundary interval brachiopod data. *Vellamo*, a typical Ordovician genus, ranges up to 30 cm above the oncolitic platform bed, member 7, Ellis Bay Formation. As with the trilobites, the next 40 m of the lower Becscie contains few diagnostic brachiopods (e.g., *Parastrophinella reversa* in growth position; *Stricklandia* sp.). At about 100 m above the base of the Becscie is the first appearance of *Virgiana* sp., a level which Lésperance considers may be as low as the *A. acuminatus* Zone or *Cystograptus vesiculosus* Zone.

The distribution of the atrypoid brachiopods was reviewed by Copper (1981). Three species of *Spirigerina* occur in the Ellis Bay Formation and this genus is only known elsewhere in North America Ordovician strata from the Edgewood Group, Missouri (?Gamachian). Different forms of this genus, together with *Atrypina gamachiana* (Twenhofel), occur above the oncolitic platform bed which Copper (1981) considered as a suitable level for the systemic boundary. *Zygospiraella planoconvexa*, a typical Rhuddanian index fossil, occurs higher in the lower Becscie, below or at a level where *Virgiana* and the trilobite *Acernaspis* occur (e.g. Lésperance 1985: figs 3, 4).

Cocks & Copper (1981) reported a *Hirnantia* fauna from a thin interval, 4.5 m below the oncolitic platform bed, in eastern Anticosti. This level is about 5 m below the occurrence of Silurian conodonts at this locality (Nowlan 1982). Since no internal moulds were illustrated, Lésperance (1985) has queried the assignment of these brachiopods to the *Hirnantia* fauna, but recognized that this fauna does appear at an equivalent level to the south in the Gaspé region.

Other macrofossils. Although commonly abundant in the Anticosti sequence, insufficient work has been completed or published on other groups of macrofossils to add much resolution to defining the systemic boundary in this region. Aulacerid stromatoporoids range only into member 7, Ellis Bay Formation and are present in the oncolitic platform bed (Bolton 1981; Cocks & Copper 1981; Petryk 1982c). The global change from a labechiid to a clathrodictyid assemblage near the systemic boundary was documented by Webby (1980). The coral genus *Calapoecia*, typically regarded as Ordovician, occurs in the bioherms and up to 20 m above the base of the Becscie Formation of Petryk (Bolton 1981). Another such Ordovician genus, *Acidolites*, is also known to extend into the upper Becscie Formation (Bolton 1981) and the distribution of species on Anticosti, especially in the member 7 bioherms, has been documented by Dixon (1986). Some preliminary work on algae, including those in the bioherms, have been published by Copper (1977), Bolton (1981), and Gauthier-Coulloudon & Mamet (1981). Bolton (1981) reviewed the occurrence of echinoderms, molluscs, and bryozoans but none of these groups is sufficiently well documented to be of biostratigraphical value for the boundary interval.

Micropalaeontology

Microfossils have been systematically collected from all of the Anticosti succession and provide the most precise biostratigraphic control. Ostracodes were investigated initially, followed by extensive conodont work, and acritarch–chitinozoan studies are now in progress with much of this collecting being tied to the conodont samples.

Ostracodes. The Anticosti ostracode faunas have been documented by Copeland (1970, 1973, 1974, 1981, 1983) for the Anticosti sequence and a series of zones and subzones established (Fig. 2). Increasing faunal provincialism occurs with the Silurian faunas (Copeland & Berdan 1977). In broadest terms, two distinct faunas occur. An older, predominantly Ordovician, hollinacean fauna is developed through the Vauréal, Ellis Bay and the lower 35 m of the Becscie formations and is assigned to the *Jonesites semilunatus* Zone with ten subzones. Much of this fauna is replaced (e.g., extinction of the Tetradellidae and Eurychiliniidae) abruptly by an endemic beyrichiacean zygobolbid fauna. However, this turnover is not precisely defined since there is a 10 m interval in the lower Becscie which yields only sparse undiagnostic ostracodes. The *Euprimitia gamachei* Subzone, the highest in the *Jonesites semilunatus* Zone, occurs in the lower 35 m of the Becscie Formation of Petryk. Copeland (1983) reported the distinctive Baltic species *Steusloffina cuneata*, considered to be of Ordovician age, from 6 m above the base of the Becscie Formation. The earliest Silurian zygobolbinid ostracodes occur about 40–50 m above the first occurrence of *Virgiana* and *Acernaspis* and 70 m above the first appearance of Silurian conodonts. Most of the ostracode distributions are plotted by member and/or formation by Copeland (1970, 1973, 1974) which limits the degree of resolution of ostracode biostratigraphy.

Palynomorphs. The chitinozoan faunas from the Vauréal and Ellis Bay formations have been described by Achab (1977a, b, 1981). A doctoral study of the latest Ordovician and the Silurian acritarchs was undertaken by Duffield (1982) and the preliminary results published (Duffield & Legault 1981). In both groups, significant turnovers occur at the level of the bioherms similar to that of the conodonts (see below).

For the chitinozoans, members 5 and 6 contain *Conochitina gamachiana* Achab, *C. micrantha* Eisenack and *C. taugourdeau* Eisenack, which range up to the base of the bioherms. Above the bioherms, the fauna consists only of *Cyathochitina kuckersiana* Eisenack and *Ancyrochitina spongiosa* Achab with *Conochitina* sp. 1 of Achab higher in the Becscie.

The acritarch floral assemblage of the upper Ellis Bay Formation is of low diversity and abundance. Dominant taxa are *Baltisphaeridium plicatispinae* Gorka and *Multiplicisphaeridium* sp. 1 of Duffield & Legault. These taxa dominate up to the bioherms but the 2 m biohermal interval is generally barren of acritarchs. Some taxa range into the overlying Becscie but above the bioherms several new distinctive taxa appear including *Goniosphaeridium oligospinosum*, *Multiplicisphaeridium birminghamensis* and members of the *M. denticulatum* group. This diverse upper assemblage contains forms described elsewhere from Silurian strata in North America and Belgium.

Conodonts (Plates 1–3). The entire Anticosti outcrop was sampled at 2 m intervals for conodonts by Barnes and later expeditions have provided more intensive collections, particularly in the boundary interval. In all, some 700 samples have yielded over 150 000 conodonts. Most of the basic taxonomic and biostratigraphical results have now been published (McCracken & Barnes 1981a; Nowlan & Barnes 1981; Uyeno & Barnes 1983); for the upper Becscie–Gun River interval only preliminary results have appeared (Fåhræus & Barnes 1981). These data have been important in a revision of North American chronostratigraphy using the Anticosti sequence as a reference section (Barnes & McCracken 1981; Barnes, in press) for the Gama-chian, Menierian and Jumpersian stages (Fig. 2).

The Vauréal Formation yielded a diverse and particularly abundant conodont fauna of Richmondian age (Nowlan & Barnes 1981). The pattern of conodont communities reflects the gradually upward-shallowing sequences with *Phragmodus* and *Amorphognathus*–*Plectodina* dominated assemblages eventually being replaced by an *Oulodus*–*Aphelognathis* assemblage (Nowlan & Barnes 1981: figs 2, 3).



In the upper Vauréal a new distinctive genus, *Gamachignathus*, appears (McCracken *et al.* 1980) and then dominates the fauna of the entire Ellis Bay Formation, particularly the western sections. The Ellis Bay fauna contains many taxa ranging up from the Vauréal Formation but also new taxa such as *Aphelognathus* sp. aff. *A. grandis* and *Staufferella inalignera* as well as an absence of *Plectodina*. McCracken & Barnes (1981a) established conodont Fauna 13 for this Ellis Bay interval (following Faunas 1–12 of Sweet *et al.* (1971); see also Sweet (1984) for new conodont chronozones). This *Gamachignathus* fauna has since been recognized in other latest Ordovician marginal basins in North America, including the Matepedia Group, Gaspé (Nowlan 1981) and the Grog Brook Group, New Brunswick (Nowlan 1983), the Hanson Creek Formation, Ely Springs Dolomite, and Unnamed Limestone at Ikes Canyon, Toquima Range, Nevada and California (Ross *et al.* 1982: C11), the Fish Haven Dolomite of Utah (Leatham 1985), the Road River Formation of the Yukon (McCracken & Nowlan in press; McCracken & Lenz in press) and the Cape Phillips Group, Cornwallis Island, Canadian Arctic Archipelago (McCracken & Nowlan in press). This distinctive genus appears to have evolved in the latest Richmondian from *Birksfeldia* (Barnes & Bergström, this volume, p. 325).

McCracken & Barnes (1981a: fig. 12) have shown the distribution of nearly 40 form and multielement conodont species through the members of the Ellis Bay Formation. A remarkable turnover in the fauna occurs at the level of the bioherms. The Ordovician taxa range up to a level 50 cm above the oncolitic platform bed, that is in the lower 50 cm of the interbiohermal strata. At this level, taxa typical of the Silurian first appear (e.g. *Ozarkodina oldhamensis*). These intermingle with only a few taxa extending from underlying strata: *Gamachignathus ensifer*, *G. hastatus*, *Oulodus robustus* and the coniform taxa of *Panderodus*, *Pseudooneotodus*, *Decoriconus*, *Walliserodus* and *Staufferella*. Of these, *Gamachignathus* and *Staufferella* become extinct 1.5–2.0 m higher in the section, at the base of the Becscie Formation of Petryk. Within a few metres of the first appearance of Silurian conodonts, several other distinctive Silurian taxa appear including *Distomodus* sp. aff. *D. kentuckyensis*, *Icriodella discreta*, *I. deflecta*, *Oulodus? kentuckyensis*, *O.? nathani* and *Spathognathodus manitoulinois*. The base of the Silurian on Anticosti was defined using conodonts as the first appearance of *Ozarkodina* (*O. hassi* and/or *O. oldhamensis*) (McCracken & Barnes 1981a; Barnes & McCracken 1981). These authors also

PLATE 1 All figures $\times 70$ except fig. 2 $\times 100$, fig. 11 $\times 85$ and figs 12, 13, and 17 $\times 35$. Type specimens deposited in the Geological Survey of Canada, Ottawa; sample number given in parentheses after GSC type number.

Figs 1–8 *Gamachignathus hastatus* McCracken, Nowlan & Barnes. (1, 6) Posterior and inner lateral views of keislognathiform elements; GSC 84971, GSC 84976 (S-1). (2, 5) Inner lateral views of cyrtioniodiform elements; GSC 84972, GSC 84975 (S-1). (3) Posterior view of hibbardelliform element; GSC 84973 (S-1). (4, 7) Outer lateral and inner lateral views of modified prioniodiform elements; GSC 84974 (S-1), GSC 84977 (2B-2). (8) Outer lateral view of cordylodiform element; GSC 84978 (2B-3).

Figs 9–19 *Gamachignathus ensifer* McCracken, Nowlan & Barnes. (9) Inner lateral view of cyrtioniodiform element; GSC 84979. (10) Posterior view of keislognathiform element; GSC 84980. (11) Posterior view of hibbardelliform element; GSC 84981. (12, 13) Inner lateral and outer lateral views of modified prioniodiform elements; GSC 84982, GSC 84983. (14, 16, 17) Inner lateral, inner lateral and outer lateral views of prioniodiform elements; GSC 84984, GSC 84986, GSC 84987. (15, 18) Inner lateral and outer lateral views of cordylodiform elements; GSC 84985, GSC 84988. (19) Inner lateral view of falodiform element; GSC 84989. All specimens from sample S-1.

Figs 20, 24 *Pseudobelodina dispansa* (Glenister). (20) Lateral view of furrowed element; GSC 84990. (24) Lateral view of non-furrowed element; GSC 84994. Both specimens from sample S-1.

Figs 21–23 *Phragmodus undatus* Branson & Mehl. (21) Inner lateral view of trichonodelliform element; GSC 84991. (22) Outer lateral view of oistodiform element; GSC 84992. (23) Inner lateral view of cordylodiform–cladognathiform element; GSC 84993. All specimens from sample S-1.

Figs 25, 26 *Plegagnathus dartoni* (Stone & Furnish). (25) Outer lateral view of recurved element; GSC 84995 (S-145). (26) Inner lateral view of reclined element; GSC 84996 (S-1).

Figs 27, 28 *Pseudobelodina vulgaris vulgaris* Sweet. (27) Inner lateral view of broadly curved element; GSC 84997 (S-1). (28) Outer lateral view of tightly curved element; GSC 84998 (S-1).



established the *Oulodus? nathani* Zone for the earliest Silurian strata, lying below the *Discomodus kentuckyensis* Zone known elsewhere in North America (Fig. 2). In all the Anticosti conodont studies this conodont faunal turnover is by far the most profound and it is also a global event (Barnes & Bergström, this volume). In other carbonate sequences this same sharp boundary level can also be recognized. The *O.? nathani* Zone has been recognized elsewhere, for example in Gaspé, Quebec (Nowlan 1983) and the Oslo region of Norway (Aldridge & Mohamed 1982) based on the presence there of *O.? cf. O. nathani*.

The precise conodont faunal changes across the systemic boundary at the Ellis Bay and Salmon River sections, western and east-central Anticosti, were documented by McCracken & Barnes (1981a: figs 12, 14, tables 1–7). Cluster analysis was used to determine the changing community patterns with time, particularly with respect to east–west facies change. Additional collecting across the boundary interval was made by Duffield & Barnes in 1979 and the author in 1982 at Pointe Laframboise (Petryk 1981a: fig. 11), and west and east sides of Ellis Bay (Petryk 1981a: figs 12, 14) and at Salmon River (Petryk 1981a: figs 22, 23). These sections are described in both McCracken & Barnes (1981a) and Barnes *et al.* (1981).

The new conodont data are shown in Fig. 3 and Table 1. These three sections were closely sampled in each of these three sets of collections, resulting in sampling across the boundary interval at 10–20 cm intervals with each sampled interval being about 10 cm in thickness. In all, over 250 samples were taken through the 4–5 m interval at these three sections. The number of specimens per species per sample were tabulated by McCracken & Barnes (1981a) and Table 1 herein records similar data for the 1979 and 1982 collections. The latter two collections were taken close to the bioherms and produced much lower yields. Conodonts in general are rare in biohermal facies and to test this in the Anticosti sequence several samples (e.g. 2A.13–2A.15; 2B.14–2B.15) were taken from within the bioherms (Figs 3, 4B). All but one were barren and the exception contained only one specimen.

The faunal change occurring in this boundary interval described by McCracken & Barnes (1981a) and further by McCracken & Nowlan (in press), is substantiated in the new collections at each of the three sections. Some slight adjustments to the ranges of certain species can be noted. The general pattern is of an assemblage of Ordovician taxa up to the level of, and including, the oncolitic platform bed, member 7, Ellis Bay Formation, dominated by *Gamachignathus ensifer* and *G. hastatus*. At both the Pointe Laframboise and west side of Ellis Bay

PLATE 2 All figures $\times 70$ except figs 3, 6, 11, 17, 24, and 26 $\times 85$, figs 7, 16, 18–23 and 27 $\times 35$ and fig. 10 $\times 60$. Sample numbers are as shown in Fig. 3, p. 211, except for S-143, 2 m below S-144; C-24, 1 m below oncolitic platform bed, east side Ellis Bay (Loc. 2C; Fig. 1).

Figs 1–3, 6–8 *Oulodus robustus* (Branson, Mehl & Branson). (1) Posterior view of zygnathiform element; GSC 85032 (2B-3). (2) Inner lateral view of cordylodiform element; GSC 85033 (2B-3). (3, 6). Inner lateral views of eoligonodiniiform elements; GSC 85034, GSC 85037 (2B-3). (7) Outer lateral view of prioniodiniiform element; GSC 85038 (C-24). (8) Posterior view of oulodiform element; GSC 85039 (2B-3).

Figs 4, 5, 9, 10, 12 *Oulodus ulrichi* (Stone & Furnish). (4) Inner lateral view of eoligonodiniiform element; GSC 85035 (2B-3). (5, 9) Posterior views of zygnathiform elements; GSC 85036, GSC 85040 (2B-3). (10) Posterior view of trichonodelliform element; GSC 85041 (2B-3). (12). Posterior view of oulodiform element; GSC 85043 (S-143).

Figs 11, 13–19 *Oulodus rohneri* Ethington & Furnish. (11, 13) Posterior views of trichonodelliform elements; GSC 85042, GSC 85044 (2B-3). (14, 16) Posterior views of zygnathiform elements; GSC 85045, GSC 85047 (2B-3). (15) Inner lateral view of eoligonodiniiform element; GSC 85046 (2B-3). (17) Inner lateral and posterior views of prioniodiniiform element; GSC 85048 (S-143). (18, 19) Posterior view of oulodiform elements; GSC 85049, GSC 85050 (S-143).

Figs 20–27 *Aphelognathus* sp. aff. *A. grandis* Branson, Mehl & Branson. (20) Posterior view of trichonodelliform element; GSC 85051. (21, 26) Posterior views of zygnathiform elements; GSC 85052, GSC 85057. (22) Inner lateral view of cyrtioniodiform element; GSC 85053. (23, 27) Lateral views of aphelognathiform elements; GSC 85054, GSC 85058. (24) Inner lateral view of eoligonodiniiform element; GSC 85055. (25) Inner lateral view of prioniodiniiform element; GSC 85056. All specimens from sample S-143.

Table 1 Distribution of conodont species in the Ordovician–Silurian boundary interval, Anticosti Island, Québec. A: Pointe Laframboise (Locality 2A; Fig. 1). B: West side of Ellis Bay (Locality 2B; Fig. 1). C: 9 mile pool, Salmon River (Locality 5B; Fig. 1). Stratigraphical position of samples shown in Fig. 3 from collections by

Table 1A: Pointe Laframboise (Loc. 2A)														
Species/Sample number	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	
<i>Amorphognathus ordovicicus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Aphelognathus</i> aff. <i>A. grandis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Decoriconus costulatus</i>	—	—	—	—	—	—	—	—	—	—	—	1	—	
<i>Drepanoistodus suberectus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Gamachignathus ensifer</i>	—	23	3	9	1	7	6	3	—	—	—	—	—	
<i>G. hastatus</i>	—	22	—	—	—	—	—	—	—	—	—	—	—	
<i>Oulodus robustus</i>	—	25	—	—	—	—	—	—	—	—	—	—	—	
<i>O. rohneri</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>O. ulrichi</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Panderodus</i> spp.	—	—	1	1	—	—	—	—	—	2	186	76	8	
<i>Phragmodus undatus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Plegagnathus dartoni</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Pseudobelodina dispansa</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>P. v. vulgaris</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Pseudooneotodus beckmanni</i>	—	3	1	—	—	—	—	—	—	—	—	2	—	
<i>Staufferella inaligera</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Walliserodus</i> cf. <i>W. curvatus</i>	—	2	2	1	—	—	—	—	—	—	—	—	—	
<i>Distomodus</i> aff. <i>D. kentuckyensis</i>	—	—	—	—	—	—	—	—	1	2	—	—	—	
<i>Icriodella discreta</i>	—	—	—	—	—	—	—	—	—	—	5	—	11	
<i>Oulodus?</i> <i>kentuckyensis</i>	—	—	—	—	—	—	—	—	—	—	2	—	1	
<i>O.?</i> <i>nathani</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
<i>Ozarkodina hassi</i>	—	—	—	—	—	4	—	—	—	—	13	22	2	
<i>O. oldhamensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	
(+ ramiforms of <i>O. hassi</i>)	—	—	—	—	6	3	5	5	—	—	72	56	2	
<i>Spathognathodus manitoulinensis</i>	—	—	—	—	—	—	—	—	1	2	—	—	—	
<i>Walliserodus curvatus</i>	—	—	—	—	—	—	—	—	—	—	38	31	—	
Total specimens/sample	0	75	7	11	7	14	11	8	2	6	316	188	24	

Duffield & Barnes, and Barnes; distribution data for other samples given in McCracken & Barnes (1981a). Average sample weight is 2 kg.

2A-1	2A-2	2A-3	2A-4	2A-5	2A-6	2A-7	2A-8	2A-9	2A-10	2A-11	2A-12	2A-13	2A-14	2A-15
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	5	2	—	—	—	—	—	1	4	—	—	—	—	—
—	—	—	2	—	—	—	—	—	—	—	—	—	—	—
—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	1	2	—	1	—	—	—	6	—	1	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	1	—	—	—	—	—	—	1	—	—	—
—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
—	—	—	—	—	—	—	—	1	—	—	4	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
—	—	—	—	—	—	—	—	—	3	—	—	—	—	1
—	—	—	—	—	—	1	—	—	—	1	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	10	3	4	2	1	1	0	2	13	1	9	0	0	1

Table 1B: West side, Ellis Bay (Loc. 2B)

Species/Sample number	H17	H18	H19	H20	H21	H22	H23	2B-1	2B-2
<i>Amorphognathus ordovicicus</i>	—	—	—	—	—	—	—	—	—
<i>Aphelognathus</i> aff. <i>A. grandis</i>	—	—	—	—	—	—	—	—	—
<i>Decoriconus costulatus</i>	—	—	—	—	7	—	—	—	—
<i>Drepanoistodus suberectus</i>	—	—	—	—	—	—	—	—	—
<i>Gamachignathus ensifer</i>	34	6	6	—	—	—	—	—	2
<i>G. hastatus</i>	—	—	—	—	—	—	—	—	4
<i>Oulodus robustus</i>	23	—	—	—	—	—	—	—	2
<i>O. rohneri</i>	—	—	—	—	—	—	—	—	—
<i>O. ulrichi</i>	—	—	—	—	—	—	—	—	—
<i>Panderodus</i> spp.	—	—	—	3	161	5	22	—	1
<i>Phragmodus undatus</i>	—	—	—	—	—	—	—	—	—
<i>Plegagnathus dartoni</i>	—	—	—	—	—	—	—	—	—
<i>Pseudobelodina dispansa</i>	—	—	—	—	—	—	—	—	—
<i>P. v. vulgaris</i>	—	—	—	—	—	—	—	—	—
<i>Pseudooneutodus beckmanni</i>	8	—	—	—	54	—	1	—	—
<i>Staufferella inaligera</i>	—	—	—	—	—	—	—	—	—
<i>Walliserodus</i> cf. <i>W. curvatus</i>	—	—	—	—	—	—	—	—	—
<i>Distomodus</i> aff. <i>D. kentuckyensis</i>	—	—	—	—	—	—	1	—	—
<i>Icriodella discreta</i>	—	—	—	2	9	1	16	—	—
<i>Oulodus?</i> <i>kentuckyensis</i>	—	—	—	—	1	—	—	—	—
<i>O.?</i> <i>nathani</i>	—	—	—	—	—	—	—	—	—
<i>Ozarkodina hassi</i>	—	4	4	—	—	—	14	—	—
<i>O. oldhamensis</i>	—	—	—	—	—	—	—	—	—
(+ ramiforms of <i>O. hassi</i>)	—	—	—	—	26	—	—	—	—
<i>Spathognathodus manitoulinensis</i>	—	—	—	—	—	—	—	—	—
<i>Walliserodus curvatus</i>	—	—	—	—	24	—	—	—	—
Total specimens/sample	65	10	10	5	282	6	54	0	9

(2B-3 & 2B-4)	2B-5	2B-6	2B-7	2B-8	2B-9	2B-10	2B-11	2B-12	2B-13	2B-14	2B-15
2	—	—	1	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
1	1	1	—	—	—	—	1	1	—	—	—
32	—	—	—	—	1	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	2	30	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
1	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1	—	—	—
—	—	—	1	1	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1	3	—	—
—	—	—	—	—	—	—	—	—	1	—	—
—	—	—	—	—	—	1	1	—	—	—	—
—	—	—	—	—	—	1	—	—	—	—	—
—	—	—	—	—	—	—	—	—	2	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	3	—	—
53	1	1	2	1	1	3	2	5	39	0	0

Table 1C: Salmon River (Loc. 5B)

Species/Sample number	S144	S145	S146	S147	S148	S149	S150	S151	S152	S153	S1	S2	S3	S4	S5	S6	S7	S8
<i>Amorhognathus ordovicicus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Aphelognathus</i> aff. <i>A. grandis</i>	—	17	—	—	—	—	—	—	—	—	38	—	—	—	—	—	—	—
<i>Decoriconus costulatus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Drepanoistodus suberectus</i>	—	6	—	—	—	—	—	—	—	—	15	—	—	—	—	—	—	—
<i>Ganachignathus ensifer</i>	10	25	10	—	—	—	—	—	—	—	39	3	13	23	—	—	13	—
<i>G. hastatus</i>	1	5	—	—	—	—	—	—	—	—	34	—	—	—	—	—	—	—
<i>Oulodus robustus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—
<i>O. rohneri</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>O. ulrichi</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Panderodus</i> spp.	6	19	3	10	—	5	200+	18	200+	54	98	11	6	—	—	—	—	—
<i>Phragmodus undatus</i>	2	1	—	—	—	—	—	—	—	—	3	—	—	—	—	—	—	—
<i>Plegagnathus dartoni</i>	—	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
<i>Pseudobelodina dispansa</i>	—	1	—	—	—	—	—	—	—	—	6	—	—	—	—	—	—	—
<i>P. v. vulgaris</i>	—	1	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—
<i>Pseudooneotodus beckmanni</i>	—	3	2	—	—	1	45	6	30	11	2	—	—	—	—	—	—	—
<i>Staufferella inaltigera</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Walliserodus</i> cf. <i>W. curvatus</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Distomodus</i> aff. <i>D. kentuckyensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<i>Icriodella discreta</i>	—	—	—	—	—	3	—	—	1	—	—	—	—	—	—	—	—	—
<i>Oulodus? kentuckyensis</i>	—	—	—	—	—	3	—	—	—	1	—	—	—	—	—	—	1	—
<i>O.? nathani</i>	—	—	—	—	—	—	2	—	—	1	—	—	—	—	—	—	1	2
<i>Ozarkodina hassi</i>	—	—	—	—	—	2	4	—	—	1	—	—	—	6	—	10	—	—
<i>O. oldhamensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(+ ramiforms of <i>O. hassi</i>)	—	—	3	1	—	—	30	3	57	7	—	—	—	7	—	10	12	—
<i>Spathognathodus manitowlinensis</i>	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	4
<i>Walliserodus curvatus</i>	—	—	—	10	—	4	16	—	15	5	—	—	—	—	—	—	—	—
Total specimens/sample	19	79	18	21	0	18	297+	27	303+	80	241	14	19	40	0	20	28	6

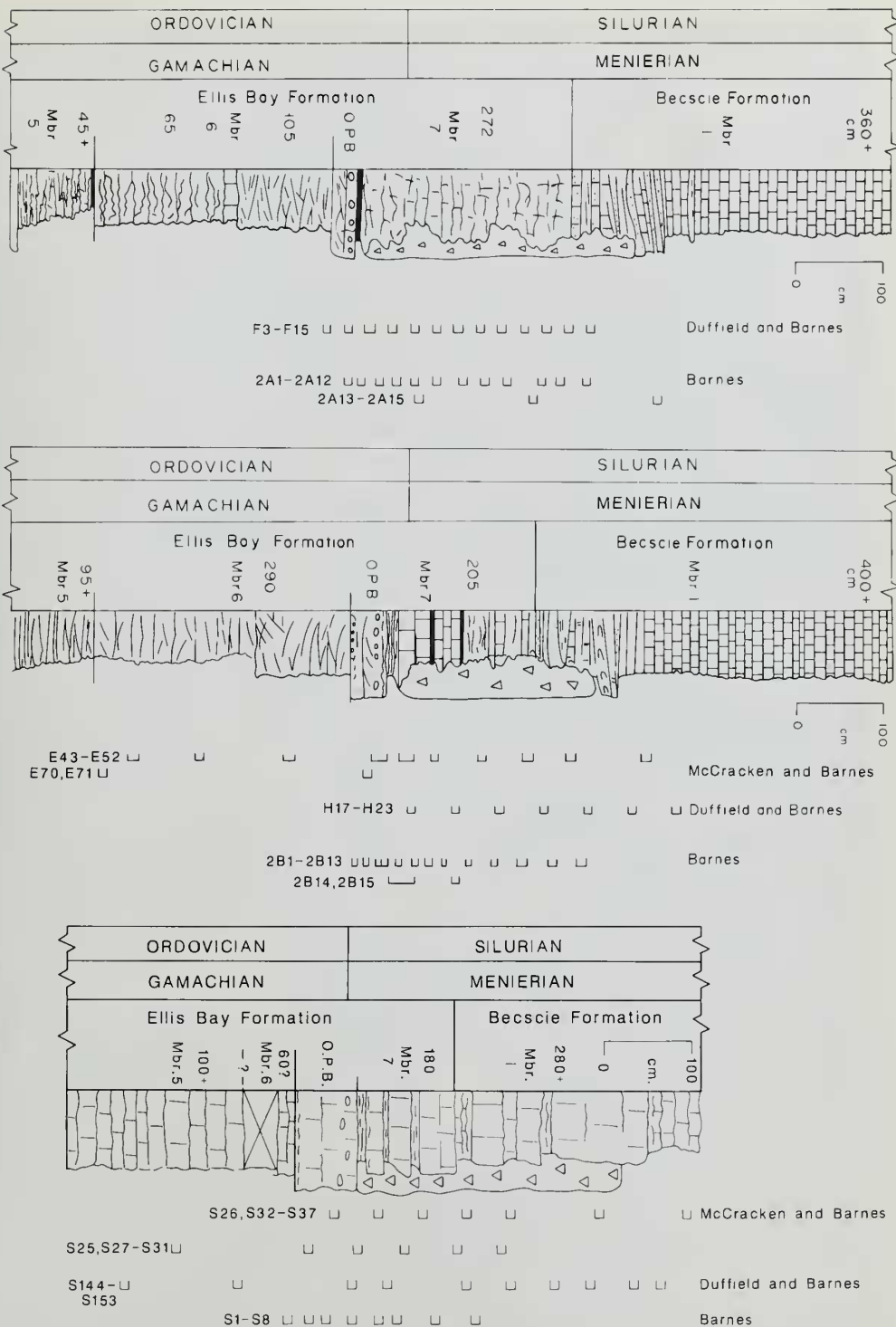
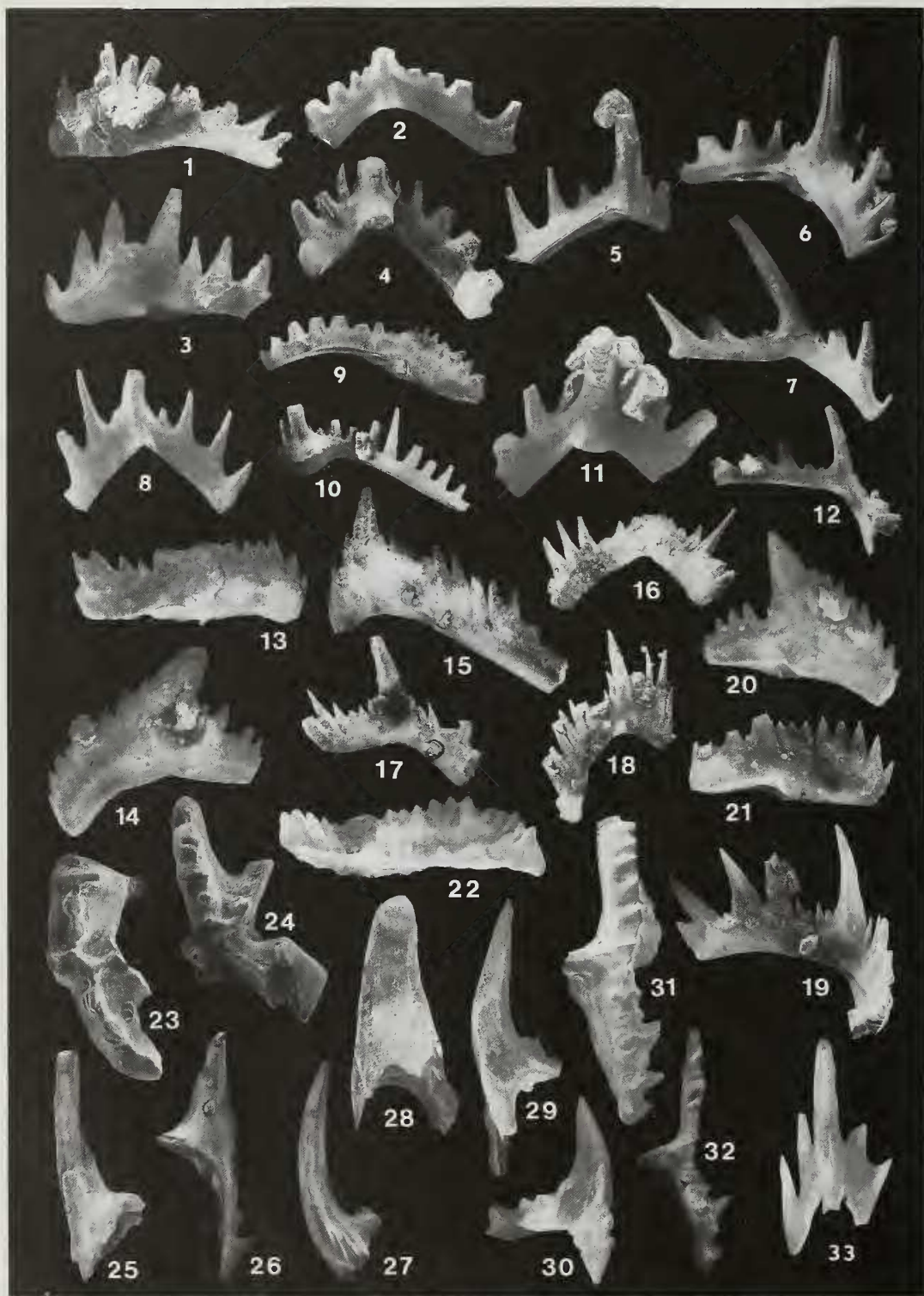


Fig. 3 Detail of lithostratigraphy of the Ordovician-Silurian boundary interval at Pointe Laframboise (left), west side of Ellis Bay (centre) and Salmon River (right) (Localities 2A, 2B, and 8B respectively on Fig. 1) showing position of conodont samples collected by McCracken & Barnes, Duffield & Barnes, and Barnes. Conodont distribution data from these samples given by McCracken & Barnes (1981a) and in Table 1 herein.

OPB = oncotic platform bed.



sections (Localities 2A, 2B, on Fig. 1), the first Silurian taxa (*Ozarkodina oldhamensis*, *O. hassi*, *Spathognathodus manitoulinensis* and *Oulodus? nathani*) appear about 90 cm above the base of the oncolitic platform bed, that is 50 cm above the top of this bed within the interbiohermal strata (Fig. 4D). At the Salmon River section (Locality 5B on Fig. 1; Fig. 4F), the later collections show the first occurrence to be still 90 cm above the base of the oncolitic platform bed but since this bed has thickened to 90 cm, from 40 cm in the western sections, the top 10 cm of this bed have now yielded Silurian taxa (Table 1). This is about 50 cm lower than the level reported by McCracken & Barnes (1981a) and perhaps the level reported by Nowlan (1982) from a coastal section further to the east. In the three sections, *Gamachignathus*, *Oulodus robustus* and *Staufferella inaligera* range through the next two metres, mixed with the early Silurian forms. At a level approximating to the base of Petryk's Becscie Formation (typically 2 m above the base of the oncolitic platform bed, and equivalent to a level within a metre of the top of the bioherms) these residual Ordovician taxa disappear and the earlier Silurian taxa are joined by other Silurian forms such as *Icriodella discreta*, *Icriodella deflecta*, *Distomodus* sp. aff. *D. kentuckyensis* and *Oulodus? kentuckyensis*.

Biostratigraphical correlations

This paper has reviewed the sequence of faunas through the systemic boundary interval on Anticosti and added new conodont data. Many of the references noted above include sections on the regional biostratigraphical correlations. Space limitations prevent a comprehensive dis-

PLATE 3 All figures $\times 70$ except figs 4–8, 18, 20, 21 $\times 85$ and fig. 31 $\times 35$. Sample numbers are as shown in Fig. 3, p. 211, except for S-154, S-155, 2 and 1.5 m above S-153; C-38 in Lower Becscie, 1.2 km east of Cap à l'Aigle (Loc. 3B; Fig. 1); F-16 is 2 m above F-15.

Figs 1–8 *Oulodus? nathani* McCracken & Barnes. (1, 3) Inner lateral views of modified oulodiform elements; GSC 84999, GSC 85001. (2) Posterior view of trichonodelliform element; GSC 85000. (4, 8) Posterior view of zygognathiform elements; GSC 85002, GSC 85006. (5, 6) Inner lateral views of lonchodiniiform elements; GSC 85003, GSC 85004. (7) Inner lateral view of ligonodiniiform element; GSC 85005. All specimens from sample S-154 except (1) which is from sample C-38.

Figs 9–12 *Oulodus? kentuckyensis* (Branson & Branson). (9) Lateral view of modified oulodiform element; GSC 85007 (F-15). (10) Lateral view of eupriodiodiniiform element; GSC 85008 (S-153). (11) Posterior view of zygognathiform element; GSC 85009 (S-154). (12) Inner lateral view of ligonodiniiform element; GSC 85010 (S-154).

Figs 13, 14 *Ozarkodina oldhamensis* (Rexroad). (13) Lateral view of spathognathodiform element; GSC 85011 (S-155). (14) Inner lateral view of ozarkodiniiform element; GSC 85012 (S-155).

Figs 15–19 Ramiform elements of *O. oldhamensis* and *O. hassi* complex. (15) Lateral view of synprioniodiniiform element; GSC 85013. (16) Posterior view of zygognathiform element; GSC 85014. (17, 19) Inner lateral views of ligonodiniiform elements; GSC 85015, GSC 85017. (18) Posterior view of trichonodelliform element; GSC 85016. All specimens from sample S-155.

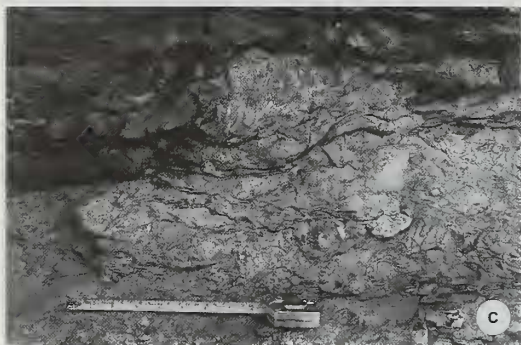
Figs 20, 21 *Ozarkodina hassi* (Pollock, Rexroad & Nicholl). (20) Inner lateral view of ozarkodiniiform element; GSC 85018 (S-153). (21) Lateral view of spathognathodiform element; GSC 85019 (2A-10).

Fig. 22 *Spathognathodus manitoulinensis* Pollock, Rexroad & Nicholl. Inner lateral view of spathognathodiform element; GSC 85020 (S-8).

Figs 23–28 *Distomodus* sp. aff. *D. kentuckyensis* Branson & Branson. (23, 24) Upper view of platform elements; GSC 85021, GSC 85022. (25) Inner lateral view of distomodiform element; GSC 85023. (26) Inner lateral view of modified ambalodiform element; GSC 85024. (27) Inner lateral view of eoligonodiniiform element; GSC 85025. (28) Posterior view of zygognathiform element; GSC 85026. All specimens from sample F-16.

Figs 29–31, 33 *Icriodella discreta* Pollock, Rexroad & Nicholl. (29) Outer lateral view of sagitododontiform element; GSC 85027 (2B-13). (30) Inner lateral view of ambalodiform element; GSC 85028 (2B-13). (31) Upper view of icriodelliform element; GSC 85029 (2B-12). (33) Posterior view of trichonodelliform element; GSC 85031 (2B-13).

Fig. 32 *Icriodella deflecta* Aldridge. Upper view of icriodelliform element; GSC 85030 (C-55; base of Gun River Formation, Locality 5C on Fig. 1).



cussion here of the correlations suggested by all the different fossil groups. Fairly precise correlations can be made from Anticosti to the various sections in Gaspé and New Brunswick, to sections in central and western North America, and to Norway (e.g. Lespérance 1985; Barnes & Bergström, this volume, p. 325). These correlations can be effected best through use of conodonts, ostracodes, shelly fossils and palynomorphs (Fig. 2).

The more difficult correlation is with oceanic graptolitic sequences, for example with the Dob's Linn stratotype. This problem has been addressed from different viewpoints by Barnes & Bergström; Barnes & Williams; and Riva (all in this volume). There is no precise correlation since Dob's Linn contains few fossils other than graptolites and these are rare in the Anticosti boundary interval. Barnes & Bergström (this volume) conclude that the conodont faunal turnover, so dramatically seen on Anticosti and elsewhere, must occur at a level within the upper *Glyptograptus persculptus* Zone up to, but no higher than, the base of the *Akidograptus acuminatus* Zone (the formally defined base of the Silurian). The major extinction event in conodonts and graptolites thus occurs within latest Ordovician time and not at the new systemic boundary. The earliest Silurian conodonts on Anticosti referred to in this paper may therefore be of latest Ordovician age (e.g. latest *G. persculptus* Zone) but at this point it is both impossible to be so precise and impractical not to refer them to the Silurian, since they are so distinctively different from Ordovician forms and form the basis for correlation in the extensive Lower Silurian carbonate platform sequences.

The conodonts, palynomorphs, aulacerid stromatoporoids, and, to a lesser extent, the brachiopods and trilobites show distinct faunal changes at essentially the same level in member 7 of the Ellis Bay Formation. Some other groups, however, seem to show a significant change within 20–50 m higher in the sequence (e.g. ostracodes, corals). Assuming that the extinctions are induced directly or indirectly by the glacial climatic events (e.g. Brenchley 1984; Barnes 1986) it is to be expected that different fossil groups would respond to such environmental pressures in different ways and at slightly different times.

Future studies and potential

The beauty of Anticosti Island is not only in its modern fauna, flora and scenery but in the magnificent quality and potential of the stratigraphical sections. The Ellis Bay section has virtually all the attributes for a boundary stratotype: well exposed, continuous sedimentation, variable lithology, abundant and diverse faunas and floras, no structural deformation, little thermal alteration, geographically accessible, a reasonably sound knowledge base and long-term protection. In comparison to Dob's Linn, it lacks abundant graptolites and historical precedence. However, in most of the other criteria, the Dob's Linn section has serious weaknesses to the point at which important stratigraphical principles have been disregarded or overruled in making the final stratotype decision (Lespérance *et al.* 1987). Whereas there may be little more significant faunal data to be extracted from the well-collected Dob's Linn section,

Fig. 4 Ordovician–Silurian boundary interval, Anticosti Island, Québec. A–C, Point Laframboise (Locality 2A, fig. 1); A: 2 m tape is at level of bioherms, member 7, Ellis Bay Formation overlain by lower Becscie Formations; B: detail of biohermal–interbiohermal relationships, grainstones well developed against upper quarter of bioherm; C: detail of upper bioherm surface with crinoidal grainstones abutting and overlapping coral heads. D–G, West side of Ellis Bay, north of Cap Henri (Locality 2B, Fig. 1); D: view of cliff exposures of member 5, Ellis Bay Formation (background) and member 6 (foreground), wave platform covered by high tide; E: members 6 and 7, Ellis Bay Formation, hammer (40 cm) rests on top of oncolitic platform bed which forms base of member 7, overlain by this recessive shale and interbiohermal strata; F: similar view to E but showing bioherm developed on oncolitic platform bed above hammer; systemic boundary drawn 50 cm above top of oncolitic platform bed; G: lower Becscie Formation, hammer is 40 cm. H, Salmon River, 9 mile pool (Section 8B, Fig. 1); massive bed in centre is 90 cm oncolitic platform bed, member 7, Ellis Bay Formation, overlain by interbiohermal strata; hammer is 40 cm, earliest Silurian conodonts occur in top 10 cm of massive bed.

the Anticosti sequence will clearly continue to yield a wealth of new data and its future potential in studies through the Ordovician–Silurian boundary is probably unsurpassable. Although the systemic boundary has been decided, its reconsideration may be necessary (Lespérance *et al.* 1987). Future work will also concentrate on unravelling the type and timing of processes that caused such major extinctions. Sepkoski (1982) has calculated that 22 per cent of all families became extinct at this boundary, making it second only to the terminal Permian extinction in severity among Phanerozoic biotic crises.

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